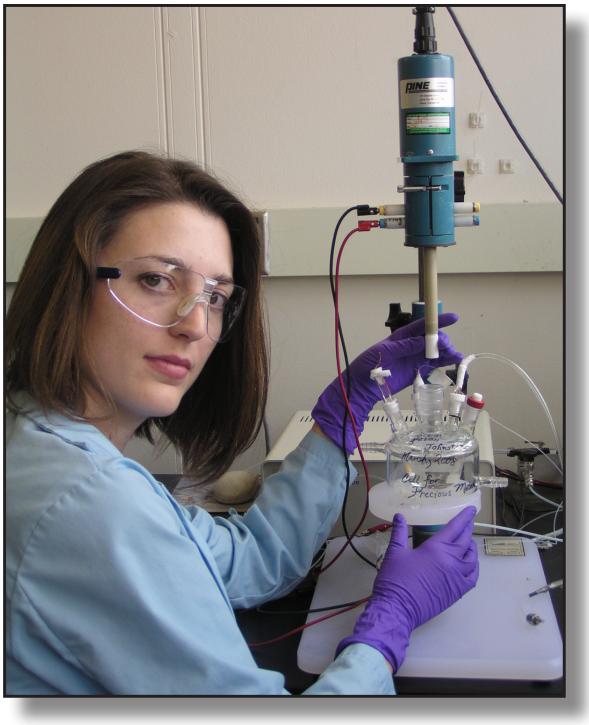
LALP-08-047 Summer 2008

Sensors and Electrochemical Devices

The Sensors and Electrochemical Devices Group (MPA-11) within the Materials Physics and Applications Division at Los Alamos National Laboratory, conducts basic and applied research on electronic and ionic conducting materials, including the development of novel materials characterization approaches. The group's groundbreaking research is the basis for new developments in device technology and applications of materials.

MPA-11's major projects include research on polymer electrolyte membrane fuel cells and related conducting polymer electrochemical devices, catalysis, spintronics devices, electrochemical sensor technology for chemical and explosives detection, electrochemical applications of high-temperature ceramics, acoustic nondestructive testing for chemical and biological agent detection, and basic and applied work on organic electronics and electroluminescent polymers.

MPA-11 supports a suite of capabilities in materials and device development and characterization, including a class 100/10,000 clean room for device fabrication, which group members use extensively in industrial collaborations.



Teams and capabilities

The Sensors and Electrochemical Devices Group is organized into research teams with specialized capabilities.

Materials chemistry

The Materials Chemistry (MC) Team characterizes fuel cell and sensor materials and devices and has extensive experience in both ceramic- and polymer-based materials used in fuel cells, sensors, permeation membranes, and electrolysis.

The MC Team also performs research and development on materials for solid-state energy conversion applications and solid-state chemical sensors for a variety of applications. It conducts research on oxide thin films, ion transport in solids, gas separation membranes, fuel cell and hydrogen storage materials, and oxide materials chemistry. In addition, the MC Team is developing hand-held explosives detectors for buildings, tunnels, laboratories, and public spaces, as well as for the portable detection systems needed by first-responders in emergency situations.

Using an impressive suite of analytical tools, the MC Team analyzes ion transport in solids and performs thin-film deposition and characterization of conducting materials. Our capabilities include chemical imaging of surfaces, structural characterization, and measurement of thermodynamic properties.

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Acoustics and sensors technology

The Acoustics and Sensors Technology (AST) Team develops tools for noninvasive fluid identification and characterization for physical properties determination and fluid flows measurement. It also develops novel techniques that use various forces (ultrasonic, electric, magnetic) to control movement of fluid phases such as in mixtures and emulsions. These forces are used to separate fluid/gas/solid phases. Underpinning many of the AST team's inventions is acoustic resonance and an understanding of the nature of resonance in various systems. While resonance

at low power is used for fluid diagnostic purposes, resonance at higher power is used for fluid and particle movement. One of the main techniques used by this team is swept frequency acoustic interferometry (SFAI) and its various adaptations for studying fluids, emulsions, and suspensions. In addition, this team also develops tools that employ nonlinear acoustics for imaging and material characterization. A combination of ultrasonic techniques (SFAI, nonlinear acoustics, Doppler spectroscopy, etc.) is used to visualize fluid flow and suspended microscopic particles. The team focuses on developing novel tools for solving problems for industry and the government.

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Electronic materials and devices

For more than a decade, the Electronic Materials and Devices (EMD) Team has worked with organic electronic materials and devices using a theory-fabrication-measurement approach. Research areas include condensed matter theory and experimentation, quantum chemistry, device fabrication, optical spectroscopy, and device physics. Our work has produced a better understanding of how organic light emitting diodes work, particularly in the processes controlling charge injection and transport.

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Fuel cells

The Fuel Cells (FC) Team focuses on research and development of polymer electrolyte membrane (PEM) fuel cells for commercial and military applications. Fuel cells are an important enabling technology for the hydrogen economy and have the potential to revolutionize the way the nation and the world are powered. The FC Team explores the potential of fuel cells as energy-efficient, clean, and fuel-flexible alternatives that will ultimately replace the internal combustion engine.

Research and development projects include the study of high-temperature membranes, water transport, non-precious metal catalysis, the cost and durability of fuel cell components, the optimization of fuel cell electrodes, non-Nafion membrane electrode assemblies, freeze and cold operation, impurity effects on PEM fuel cell performance/durability, as well as providing technical assistance to fuel cell developers.

Other projects include hydrogen production from liquid fuels, development of alkaline membranes and electrocatalysts, and direct methanol fuel cells. The team collaborates with universities, industry, and other national laboratories and hosts graduate students, postdoctoral researchers and guest scientists.

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Hydrogen safety, codes and standards

The potential benefits of a hydrogen economy are large and far-reaching, but the challenges are significant. MPA-11 researchers are developing safety sensors, evaluating the impact of hydrogen impurities on the operation of fuel cells, and providing technical expertise for the development of international regulations for hydrogen fuel cell vehicles.

Los Alamos National Laboratory is a leader in the performance testing and analysis of single cell tests. In collaboration with the US Fuel Cell Council, Los Alamos established the single-cell testing protocol, a series of precise fuel cell procedures that are used by research teams across the United States and around the world to perform reproducible baseline characterization. This protocol, in combination with the Laboratory's work on the effects of contaminants, will be essential in the development of fuel quality standards.

We also provide technical expertise for the United Nations/ Economic Commission for Europe's World Harmonization of Vehicle Regulations, an international collaboration working to develop and implement performance-based codes, standards, and regulations that are critical to fair and open competition in worldwide markets for hydrogen and fuel cell vehicles.

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